Computer programs have been written that affect several processes of use in mechanized documentation. Encoding programs convert source material punched on a Flexowriter into the code of a Photon photocomposing machine. The encoding programs provide justification, mixed letter size and style, and format control, to meet requirements that are specified by comments which appear ahead of the text, or, identified by special quote marks, within the text. Further programs are being written to produce the Photon code for built up chemical and mathematical formulae from "linearized" input, punched on a Flexowriter, and which contains names of symbols not on the keyboard, and control codes to indicate subscript and superscript positions. Page composing programs are being written to organize one or several texts into a complicated page format whose structure is described to the computer in simple terms. Paginated document programs are being written to organize lengthy texts into codes to print sequentially numbered pages. Editing programs have been written that apply editorial instructions to verbal texts which have been stored in a computer. At present these instructions can set margins, delete, delete and close, insert, replace, exchange and indent portions of the text, run on paragraphs and start new lines, paragraphs and pages, as requested. Programs are being written to organize fragmentary information, submitted in random sequence, into catalogues, directories, dictionaries, bibliographies, listings and indexes. Considerable emphasis is placed in all this work on modern automatic coding techniques, and on the use of "stylized instruction languages," the development of which is considered to be far more important than the actual coding of the individual programs. The following paper describes the preparation of Flexowriter source material to be converted with Photon code by a digital computer.

Computer Generation of Photocomposing Control Tapes. Part I. Preparation of Flexowriter Source Material

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I. Introduction

Many situations arise in which it is advantageous to use a computer to produce material that subsequently will be printed with the appearance of conventional publications rather than with the appearance of present-day computer output. Scientific and commercial calculations that are performed on a high speed computer and which lead to results of general interest are in this category. So are a variety of non-arithmetic computer applications that have been mooted for several years, and with which progress now is being made. Such applications include the use of computers to perform tedious algebra and analysis, to organize verbal and partly verbal material in a systematic manner, as in bibliographies, directories and other forms of tabulation, and so forth. The outcome of computer operations has been disseminated in the past either by photolithographic reproduction of material produced on line-printers, tape-operated typewriters, and similar devices, or by the lengthy processes of typesetting, running proofs, proof reading, correcting type and conventional printing.

This paper describes a technique for the printing of computer output (where the word "printing" is used in the graphic arts sense) in a completely mechanized fashion. The work that is reported here relates to the photocomposition of the output of one type of computer (the IBM 709), on one type of photocomposing unit (the Photon), which is used essentially as a paper-tape driven off-line printing device. The methods of this paper could be adapted to other forms of computer, and for purposes within their compass, to other forms of typesetting and photocomposing machine.

The difference between typesetting and photocomposing is explained briefly in section II which also contains a description of the characteristics of the Photon machine that affect the program. The absolute and relative dimensions of symbols, spaces, and blocks of printing are of prime concern in composition. Section III deals with these

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matters and includes a discussion of "justification" (production of straight margins).

The basic programs that have been developed can be used to convert material that is stored in the computer in a certain representation (which will be called the π code) into the code of the Photon machine (which will be called the ω code). The π coded material consists just of standard Hollerith characters. Material that is punched on Flexowriter tape in a further code, that will be called the ϕ code, also can be converted to the ω code by the use of the basic programs which have just been mentioned, in conjunction with some further subroutines that have been written. Letter styles and sizes, special symbols and spacing and format requirements can be represented in all three codes. It is quite easy to express this information in the ϕ and π codes, but the conversion to the ω code is very tedious and requires a computer. The ϕ and π codes are very similar; the ϕ code will be discussed in this present paper, as it is rather simpler, and also will provide the coding medium for many users who require no knowledge of the operation of the programs or of the further details of the π code. The π code will be presented as an elaboration of the ϕ code in a later paper which will discuss the programming aspects of its use, and will include the details of the various subroutines that are used.

Consideration will be given in another later paper to further sets of conventions for the representation of special symbols, built up formulae, elaborate page formats and other requirements again using a Flexowriter keyboard, but in a more concise style than is possible in ϕ code. Programs to deal with these further λ codes are under construction.

It may be mentioned here that the approach to the problem of computer-controlled photocomposition that has been adopted by the authors is linked very closely to the use of Fortran as a coding language, both for numerical computation and also for symbol manipulation. Essentially, the Fortran compiler has been modified so that source programs may contain "COMPOSE" statements which are analogous to "PRINT" statements. Each COMPOSE statement contains a reference to a FORMAT statement, and may contain the mnemonic addresses of words and arrays that contain material to be photocomposed. This material may be numerical data in standard fixed or floating point binary representation, or it may be the binary coded decimal representation of Hollerith information, and in particular this may constitute texts that have been expressed in π coded form. The FORMAT statements, to which the COMPOSE statements refer, may contain standard E, F, I, O, A and X fields, and also may contain π coded material in which Hollerith counts have been inserted.

The modified Fortran system that compiles the COMPOSE statement and the FORMAT statements containing π coding (as well as compiling all conventional Fortran material) will be called the PC1 system for reference. The system of object level programs that convert ϕ coded texts, that originate on Flexowriter tape, into ω coding to drive the Photon machine will be called the PC2 system. The set of programs that will deal with the λ codes mentioned above will form the PC3 system, and the operation of this system will involve an initial conversion of the more concise codes into ϕ or π code which then will be processed by the subroutines already in existence.

The PC1 and PC2 systems are used at present on a standard IBM 709, and standard equipment is used to convert punched paper tape to punched cards and vice versa. Also, 8 channel tape is punched on the Flexowriter, and 8 channel tape is used to drive the Photon machine.

● II. Typesetting and Photocomposition

The classical method of "setting type" as a preliminary to actual printing operations has been supplemented during the last two decades by "photocomposition". In this latter process, images of the successive characters that are to appear on a printed page are projected by an optical system onto successive positions of a sheet of photosensitive material. This is developed and used as the basis of offset or letterpress reproduction. Several models of typesetting and photocomposing equipment now are manufactured which can be controlled by paper tape. The programs that are described here enable an IBM 709 computer to produce paper tape that is coded to drive a Photon machine. The essential features of this machine that bear on the use of the programs are described below.

The images of any set of 1440 characters may be etched in eight concentric annuli on an opaque background, on a disc of certain standard dimensions, which then may be used in a continuous operation of the Photon machine for which the character set is appropriate. Several hundred different discs are in use in various Photon installations, and further discs, etched with new combinations of letters and symbols, may be produced in a simple factory operation, which involves photographing cards on which the relevant characters have been drawn. An extensive library of such cards exists. The replacement of one disc by another in the Photon machine is, moreover, a trivial manual process. When the machine is in operation, the disc rotates at high speed about a fixed axis. During each revolution of the disc, a light beam may be projected along a fixed path, through one of the annuli on the disc that is etched with characters. The illumination persists for a time interval that is very short compared with the period of rotation of the disc. An almost static image of any single character on the disc thus can be produced for a very short time interval during each rotation. The timing of the burst of illumination and the choice of annulus determine which character is displayed during any rotation. The annulus is changed whenever necessary by a mechanical displacement of the disc axis. For many applications, the switching between annuli is relatively infrequent. The image of the character that is illuminated by the light beam is focused by a lens system that determines the magnification of the character, and also the position on the photosensitive material on which the image is focused. The Photon machine can be driven by tape that contains a track specification (a track is half an annulus of characters), a lens specification (in effect a scaling factor), and then, for each of the characters to be printed, the sequence number (i.e. position around the disc) of that character, and the escapement (i.e. distance to be allowed between the left edges of that character and the next). Codes to change track number and lens size and to effect carriage returns are interspersed with the sequence number-escapement codes where necessary. The description of material to be photocomposed and the production of the necessary codes to drive the Photon machine are dominated by spacing considerations which will be considered next.

● III. Spacing Considerations

The terms that are used to describe the dimensions of printed characters, and to describe vertical and horizontal spacing in photocomposition are based on conventional type-setting practice. This makes use of slugs of metal, of rectangular cross section. Each slug is embossed at one end with the image of a character. Slugs are stocked in certain standard sizes, the size being measured by the height (or "body"), in "points". One point is a seventy-second of an inch. In general, a line of type consists of slugs of uniform body, which are embossed with characters that are commensurate with each other. The base lines of the characters on slugs of the same point size are collinear when the lower edges of the slugs are collinear (and the characters are of the same style). The base line is the lower line which most letters touch but do not cut. The exceptions (g, j, p, q, and y) are called descenders. The letters which rise above the level of an m(b, d, f, h, k, l and t) are called ascenders. The height and width of a slug, rather than the distances between portions of a visible character, thus are used to describe the character's size. The distance between the neighboring edges of two consecutive slugs in a line of type provides a simple and meaningful measure of horizontal spacing. The distance between the base lines of two consecutive lines of type, however, is used most frequently as the measure of vertical spacing. This distance is called "body lead". If successive lines consist of type of the same style and point size, and the slugs are in contact, the body lead is equal to the point size. Horizontal and vertical spaces may be measured in points or "picas" (a pica is a sixth of an inch, i.e. twelve points). It is convenient also to measure distances between pieces of type of the same body (height) in terms of this dimension. In a discussion of n-point type (i.e. type for which the slugs are $n/72$ inches high) a distance of m "relative units" is defined to be $m \times n/18$ points.

The description of letter size in terms of "point size" is retained for photocomposed material. A photocomposed character will be given the same point size as the printed character of the same style and dimensions. The same character is displayed in different point sizes, in photocomposition, by the use of different lenses, and in fact the lenses in the Photon machine are identified by the point sizes of the characters which they produce. In photocomposition, moreover, successive characters along a line are displayed with collinear base lines, regardless of their magnification (i.e. point size). Horizontal spacing is determined by ascribing a "width" to each character, that is rather greater than the maximum horizontal distance between any marks that form the character, and which corresponds to the width of the type slug in conventional composition. Each character then can be assumed to occupy a fixed position on a field of the appropriate width, and horizontal spacing described by reference to the distances between these fields. The width of any character in any style of type is made proportional to the point size, so that widths (and often spaces) are expressed most frequently in relative units. For the actual control of the Photon machine, spacing information is converted from widths and spaces as just described to "escapements". An escapement can be regarded as the distance between the left edges of the fields of two consecutive characters.

A few comments may be made here concerning justification. This can be regarded as the expansion of a line of type to some specified length by an increase in the spaces between appropriate pairs of adjacent characters. In describing a justification procedure, it is necessary to specify (i) the minimum space to be left between different pairs of characters, (ii) the spaces which may be expanded, and (iii) the limits that will be placed on the allowed expansion. In general, justification will be effected by increasing the distance between successive words for which some minimum non zero spacing has been specified. In the simplest case, each such space along a line is increased by the same amount. At times it is necessary to stipulate that only certain of the spaces in a line of type may be expanded. A further method of justification that will be used quite often involves the expansion of non zero spaces to some preset limit, with the distribution of any further spacing that may be necessary between characters whose fields otherwise would touch.

● IV. Single Line Printing

A succession of examples of increasing complexity will be described in turn. Each of these is presented in terms of the Flexowriter input to the computer which will lead to the production by the PC2 program, of output punched with the codes that are needed to control the Photon machine.

It should be noted that although different Flexowriters may have slightly different keyboard arrangements, such differences may be accommodated by trivial changes in certain tables that are used by the programs. Material that is expressed in ϕ code contains control codes that consist of ordinary letters and digits, enclosed in square brackets. The material is scanned line by line from left to right. Whenever certain control codes are encountered, the corresponding "composing parameters" that are used by the programs are reset to values that are determined by these codes:

(i) Left justified verbal matter. To compose a verbal message, starting at the left margin of the film, the appropriate ϕ code consists of the control code IN followed by the relevant message, punched in normal Flexowriter code and followed by the control code EN. Thus

The cat sat on the mat.

is composed by a Photon tape which is generated by the computer from a flexowriter tape, punched

[IN] The cat sat on the mat. [EN]

The control code IN (initialize) sets the relevant composing parameters to correspond to a page width of 36 picas (6 inches) and a page length of 45 picas (7½ inches). The width limits the extent of a text that can be displayed in a single line. It will be assumed that none of the examples of the present section reaches this limit. The setting of the page length has no effect in the present example. Its effect is considered in section V.

The code IN selects a single style of type that is determined by an entry in a table that is stored with the program. The selection of type style is represented by the setting of a certain parameter. In the case of disc No. 77 used by the authors, the IN code selects 5 point Scotch type. In general, the IN code selects the smallest type (i.e. letter size) that is available on the Photon machine. For the individual machine that is used by the authors, this corresponds to 5 point type. A gap of 4 relative units; (that is 10/9 points for the type size just mentioned) is introduced for every blank in the input. It should be noted, however, that the position of line endings in the Flexowriter input does not determine the position of line endings in the Photon output. Flexowriter input is treated as a continuous stream of information which is split into lines in the output by reference (i) to line width and justification considerations, (ii) to control codes in the input that specify the beginning of new lines explicitly or implicitly, and (iii) to paragraph breaks that are recognized in the manner described in section V. For the purposes of this present subsection, trailing blanks that follow the last non blank character on a line of Flexowriter input are treated collectively as a single blank if that character is not a period, and two blanks if it is a period. Leading blanks at the beginning of a line of Flexowriter material are retained in the output.

Ways of selecting other page sizes, other letter sizes and styles and other forms of spacing are described below. It may be noted that although the left reference line for photocomposition is the left edge of the film, the subsequent placing of the developed Photon film in the production of printing plates determines the margin widths on the final printed page.

The control code EN must appear at the end of any text that is to be photocomposed. It establishes codes in the output whose function will be discussed in the later account of the π code.

(ii) Right justified verbal matter: To compose a verbal message, that will not exceed a line of Photon output, and which will end at a position whose distance from the left margin of the film is equal to the requisite page width, the control code RJ is placed before the relevant message in the input. To compose a single line message, that is right justified but which resembles a message composed by reference to the IN code in all its other respects (i.e. letter size and style, page dimensions and spacing), the control combination IN RJ is placed before the message. When the input is processed by the PC2 program, the code IN sets all the composing parameters to values that correspond to the characteristics of the composed matter described in the preceding subsection of this paper. These characteristics include normal justification. The code RJ then resets the parameters that record the type of justification that is to be applied, without altering any of the other parameters.
As an example

[IN RJ] The cat sat on the mat. [EN]

causes the text

The cat sat on the mat.

to be composed in 5 point Scotch type, with 10/9 point spaces between words, ending 6 inches from the left margin of the film.

(iii) Centered verbal matter: A verbal message may be composed so that its mid-point occurs at a distance from the left margin of the film that is half the requisite page width, by use of the control code CR. As in the preceding example, the page width and length, letter style and letter size, spacing (and also normal justification) can be set by use of the IN code. The normal justification then can be superseded by the centering requirement, by placing the letters CR after the IN code in a control combination INCR. Thus

[INCR] The cat sat on the mat. [EN]

causes the text

The cat sat on the mat.

to be composed in 5 point Scotch type, with its center 3 inches from the left margin of the film.

(iv) Letter size control: In the examples of the preceding sub-sections no active selection has been made of type size, which has been set automatically by the IN code to 5 point. The code LSn, where n can take certain integer values in the range 5 to 28, produces characters of point size n. In the machine used by the authors, the allowed values of n are 5, 6, 7, 8, 9, 10, 11, 12, 14, 18, 24, and 28.

A type size control code can be placed after an IN code, to give normally justified Scotch type composition, on a 6 inch wide, 7½ inch long page, and a 4 relative unit space for every interword space in the input, but with a size of type (and therefore an absolute spacing) that depends on the lens code. Thus, an input tape punched

[INLS7] The cat sat on the mat. [EN]

leads to Photon output in which the sentence "The cat sat on the mat." starts at the left margin of the film and is composed in 7 point Scotch type, with 14/9 point spaces between words.

A size of type control code can be included in control combinations that effect right justification and centering. In general, a control combination that consists of a succession of control codes, is used, code by code, to set up composition requirements. Each code may change any settings to which it applies, and which were established by control codes that preceded it in a single control combination, or which were interpolated at earlier positions of the text. Thus

[INRJLS7] The cat sat on the mat. [EN]

and

[INLS7RJ] The cat sat on the mat. [EN]

both are converted to right justified 7 point Scotch type on a 6 inch wide, 7½ inch high page, with 14/9 point spacing between words.

Similarly,

[INLS7CR] The cat sat on the mat. [EN]

and

[INCRLS7] The cat sat on the mat. [EN]

are converted to 7 point Scotch type, centered at the top of a 6 inch by 7½ inch page.

Size of type can be changed as often as necessary in a line. Once the page dimensions, style of type, and justification requirements have been established by an IN, INRJ or INCR control combination, type size control codes can be interpolated by themselves at later positions of the text. Thus

[IN]The [LS6]cat [LS7]sat [LS8]on [LS10]the
[LS12]mat. [EN]

composes the sentence in Scotch type, starting at the left margin of the film, successive words appearing in 5, 6, 7, 8, 10, and 12 point type respectively. The first five words are followed by spaces of 10/9, 4/3, 14/9, 16/9 and 20/9 points respectively. The input

[IN]The[LS6] cat[LS7] sat[LS8] on[LS10]
the[LS12] mat.[EN]

composes the words in the same type sizes as before, but with spaces of 4/3, 14/9, 16/9, 20/9 and 8/3 points respectively, after the successive words.

Size of type can be changed between letters that are not separated by spaces. Thus

[IN]1[LS6]2[LS7]3[EN]

prints the digits 1, 2, 3, in 5, 6 and 7 point type respectively and without spacing.

(v) Style of type control: The codes that control the style of type are quite similar to those which have just been described for the control of size. Essentially, a style code in the Flexowriter input leads to a code, in the tape that controls the Photon machine, which selects a disc track. The inclusion of style codes in the input, presupposes a knowledge of the track numbers for the different letter styles on the disc that will be used. If n denotes the track number, the control code DLn selects the requisite track. On the disc used principally by the authors, the correspondence between track number (disc level) and letter style is summarized in Table 1. Then the input

[INDL2] The cat sat on the mat. [EN]

composes the sentence in 5 point Bodoni Bold type starting at the left margin, leaving 10/9 point spaces between words.

A style code can be combined with any of the codes discussed already, in meaningful control combinations, or can be interpolated by itself, anywhere. Thus the input

[INCR] The[DL13LS6] cat sat[LS7]
on[DL3] the[LS8] mat.[EN]

composes the sentence, centred on a 6 inch field, with the first word in Scotch type, the second, third, and fourth words in Highland type and the fifth and sixth words in Bodoni type. The first word is in 5 point, the second and third words in 6 point, the fourth and fifth words in 7 point and the sixth word in 8 point type.

In any continuous operation of the Photon machine use will be made of a single disc. In a continuous operation of the photocomposing programs on the computer it may be necessary to produce material that will apply to two or three different discs (in separate runs of the Photon). For this reason certain tabular material that is pertinent to five discs could be stored in the computer simultaneously, and the tables identified by means of the relevant disc numbers (1 to 5 digit numbers that are used for reference). The program is set to select the table for one disc automatically, under the control of the IN code, and the further code DNn is placed before material that is to be composed for a different disc, where n denotes the relevant disc number.

(vi) Special character control: All the examples have consisted so far of letters and digits. Other characters may be

TABLE I. Disc Level and Letter Style (for disc No. 77)

Disc Level	1	2	3	4	5	6	7	[illegible]
Letter Style	Scotch	Bodoni Bold	Bodoni	Scotch Small Caps	Baskerville Small Caps	Bodoni Small Caps	Techno Bold	Not Used
Disc Level	9	10	11	12	13	14	15	16
Letter Style	Scotch Italic	Bodoni Bold Italic	Bodoni Italic	Special Characters	Highland Small Caps	Baskerville Small Caps	Greek	Not Used

included in the output by specifying the appropriate disc level and disc sequence numbers in the input. The disc level has been discussed in the preceding subsection, and need be specified only when it changes. A disc sequence number n is specified in a sequence code, of the form SCn. The disc levels and sequence numbers for a few of the special characters on disc No. 77 are listed in Table 2. The corresponding tables for certain other discs are available elsewhere.

Special characters can appear anywhere in a text, and can be magnified and spaced in the same ways as ordinary alphabetic characters.

It may be mentioned here that letters, digits, and other symbols to be used as subscripts and superscripts are available on many discs, including No. 77. The base lines of such characters on the disc are displaced with respect to the normal character base line, so that they are displayed automatically in the appropriate position with respect to the characters which they append.

The ϕ code now in use may be expanded to allow the selection of pi mat characters.

Examples of ϕ coded representations of built up formulae will be provided in a later paper, which will discuss the λ codes, to be used when repeated references to table of special characters would be necessary for the preparation of λ coded input. In the simplest form of λ code, each special character will be represented in a text by a single Flexowriter character (or perhaps two or three such characters) enclosed in square brackets. The correspondence between these Flexowriter characters, and the disc levels and sequence numbers of the special characters which they represent, then will be provided to the computer in tabular form ahead of texts in which this coding device is used.

Interword spacing: In the examples considered so far, a space of four relative units has been included in the output for every Flexowriter blank (except at the ends of lines) in the input. This spacing is set by the IN code, and can be superseded by a control code MNn, where n denotes an integer, and which denotes a space of n relative units in the output wherever a valid blank occurs in the input. The term valid blank is used for any blank, except those at the end of a line which were declared redundant in subsection (i). Thus the input

[INMN8] The cat sat on the mat. [EN]

would lead to the same result as

[IN] The cat sat on the mat.[EN].

A space also can be produced in the output by the inclusion of an appropriate space code in the input. For the purpose of this section, the codes FSn and JSn, where n denotes an integer, are equivalent, and represent a space of n basic machine units (n/18 points) when n is positive, and n relative units when n is negative. Thus the input

[IN]1[FS10]2[FS20]3[FS30]4[EN]

TABLE 2.

Symbol	Disc level	Sequence no.	Symbol	Disc level	Sequence no.
× product	12	48	> greater than	12	80
÷ division	12	78	∫ integral	14	83
√ radical	12	38	∴ therefore	14	78
∞ infinity	12	39	≃ approximately	4	1
< less than	12	35	≡ identical	4	9

composes the digits 1, 2, 3, 4, in 5 point type, and with successive spaces of 5/9, 10/9, and 5/3 points respectively. The input

[INLS8]1[FS10]2[FS20]3[FS30]4[EN]

would print the digits in 8 point type, but with the same absolute spacing as before. The input

[IN]1[FS-1]2[FS-2]3[FS-3]4[EN]

would print the digits in 5 point type, with spaces of 1, 2, and 3 relative units, that is 5/18, 5/9, and 5/6 points respectively. The input

[INLS8]1[FS-1]2[FS-2]3[FS-3]4[EN]

would print the digits in 8 point type, with spaces of 1, 2, and 3 relative units again, which would correspond however to 4/9, 8/9 and 4/3 points respectively.

(viii) Page length control: The control code IN sets the page length to 45 picas (7½ inches). For the present discussion of single line composition this has no effect. To set a page length to a value of n picas, the control code PLn may be used.

(ix) Margin control: The discussion has been presented so far in terms of pages of some definite width. It is possible, however, to set up to twenty pairs of margins by means of certain control codes, and to specify which pair of margins is to be used for any portion of a line. This may be used in fitting the material that is to be printed on a line into a succession of columns. The term "sub-section" is used for the material that is to be printed between a given set of margins, and sub-sections are numbered from 1 to 20.

The first control code that sets sub-section margins is of the form STn,x,y, where n is an arbitrary number, in the range 1 to 20, that is given to the sub-section for subsequent reference. The letters x and y denote integers, and specify the distance, in picas, of the left and right margins of the sub-section, measured from the left edge of the film. A code of the form STn,x,y merely sets the values of certain parameters that later will determine the position of margins. A further code, of the form XSn, must precede the portion of text that is to be printed within the same sub-section. The initialize code, IN, implies the detailed code ST1, 0, 36 XS1. The input

[INST2, 1, 6;ST3, 13, 18ST4, 25, 30XS2] The cat[XS3] sat on[XS4] the mat.[EN] would produce output in which the successive pairs of words began at positions 1, 13 and 25 picas from the left edge of the film. As none of these pairs of words could occupy more than an inch when printed in 5 point type, the right margins are not used. If, however, the input were

```
[INRJST2, 1, 6ST3, 13, 18ST4, 25, 30XS2] The
cat[XS3] sat on[XS4] the mat.[EN]
```

the successive pairs of words would end at positions 1, 3, and 5 inches from the left edge of the film. Again, if the input were

```
[INCRST2, 1, 6, ST3, 13, 18ST4, 25, 30XS2]
The cat[XS3] sat on[XS4] the mat.[EN]
```

the successive pairs of words would be centred at $3\frac{1}{2}$, $15\frac{1}{2}$ and $27\frac{1}{2}$ picas from the left margin of the film, and if the input were

```
[INST2, 1, 6ST3, 13, 18ST4, 25, 30XS2] The
cat[CRXS3] sat on[RJXS4] the mat.[EN]
```

the first word would start 1 pica from the edge of the film, the next two words would be centred $15\frac{1}{2}$ picas from the film edge, and the last two words right adjusted to end at a position 5 inches from the left edge of the film. The STn and XSn codes can be used in conjunction with any of the other codes considered previously.

The effect of STn and XSn codes on multi-line composition is considered in section V.

Two further codes are used to set margins. These are of the form SRn,y, and SLn,y where n is an integer between 1 and 20 and y is a positive or negative integer. Each of these codes sets a boundary at a position y picas from the position which the character of the input preceding the code would occupy in the printed output. Either code may be used to reset one boundary of a sub-section already set by an STn code. Thus

```
[INST2, 1, 20] The cat[SL2, 1XS2] sat on the
mat.[EN]
```

is equivalent to

```
[IN] The cat[FS16]sat on the mat.[EN]
```

The SLn would be necessary, however, in multi line composition to align "sat" one pica beyond the end of the word "cat", and on a new line.

(x) Kill character: The code KC after a character deletes that character and leaves the space which it would have occupied. This code is used mainly in conjunction with set margin codes.

(xi) Kill line: The code KL deletes all material that has been set in the current sub-section of the current line and returns to the beginning of that sub-section to set further material. This code is used mainly to delete material that has been set merely to determine the position of a margin, that will be needed in the setting of subsequent lines.

• V. Multi-line Composition

The composition of texts containing several successive lines of material involves the consideration of vertical spacing, and of horizontal (and vertical) justification. Vertical spacing will be treated first, and the description of justification requirements will then be discussed. The subdivision of material into pages is considered last.

(i) Line control: This may be introduced by a simple example. Suppose that the successive words of the sentence

The cat sat on the mat.

are to appear at the left of successive lines of the film. The control code NL in the input starts a new line in the Photon output with the character that follows, so that

```
[IN] The[NL]cat[NL]sat[NL]on[NL]
the[NL]mat.[EN]
```

would constitute the necessary input. The IN code sets 5 point Scotch type with normal (i.e. left) justification, as mentioned already. It also sets certain parameters to values that make the distance between the base lines of each pair of successive lines of text, (i.e. the "body lead"), equal to the maximum point size of any character in the lower line of the pair. This spacing will be called "normal body lead".

Two further control codes are used to specify vertical spacing. The first is of the form SBn, where n denotes a non zero integer and sets "body lead" (distance between base lines) to n points ($n/72$ inches). It should be noted that when codes of this type (and also of the type considered next) occur within a portion of text that is to be composed on a single line, they determine the vertical spacing of that line with respect to the line above it. The code SB0 restores vertical spacing to the normal body lead mentioned earlier. The code IN implies an SB0 code.

The further code AUn, where n denotes an integer, increases the body lead by n points. If n is negative, the body lead is decreased by $|n|$ points.

The code SPn, where n denotes an integer, spaces vertically by n times the body lead value that is operative.

(ii) Horizontal justification: Consider first the case that the only control code in operation is IN, and a text of arbitrary length has been provided on Flexowriter tape. The code IN selects 5 point Scotch type (on disc No. 77), a page width of 36 picas, normal body lead, and a minimum interword spacing of four relative units. The program delimits the leading portion of the text which would occupy 36 picas, allowing the tabulated character widths for each non blank character, and four relative units of space for each input blank (except redundant trailing blanks). In general, this portion of the text ends inside a word, i.e. between two non blank characters. The last non blank character that precedes a blank (i.e. the end of the last n

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consideration of vertical
d vertical) justification.
first, and the description
then be discussed. The
s is considered last.

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t[NL]on[NL]

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lies an SB0 code.
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The last non blank
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full word) in this portion of the text is located as the end of the material that is to be printed on the current line. All the spaces between words are augmented by an equal amount, to expand the selected portion of the text to the requisite length of 36 picas. The process then is repeated line by line of the output, starting each time with the first non blank character of the input that follows the last character of the preceding justified line of the output.

The justification procedure is quite similar in the case that the IN(initialize) or RL(normal justification) code is modified by a DN(disc number) DL(disc level) LS(lens size) SB(set body lead) AU(add unit lead) or PL(page length) code, or by any of the page and section width codes ST, SR, SL and XS. An MN code sets the minimum space in the output for each non trailing blank of the input. If an RJ(right justify) or CR(centre) code is operative, justification proceeds as for the IN code until the last line is encountered, and this line then is flushed right or centred respectively.

A code of the form MXn, where n denotes an integer, alters the justification procedure slightly, by setting the maximum space which may correspond to a single blank in the input to n relative units. Any further space needed [illegible] and a line of text is inserted between characters that are not spaced in the input.

The effect of the FS and JS codes on justification also must be mentioned. These codes were introduced in subsection IV(vii). A space that is defined by an FS code cannot be augmented in any circumstances during justification. A space that is defined by a JS code is treated as a single input blank for justification purposes. Justification procedures are effected also within the range of an XSn code and merely continue setting material, line by line, within the given margin until it is exhausted or another XS code is given. At present it is not possible to effect right and left justification in several adjacent columns within a page. This facility will be provided later.

(iii) Page subdivision and vertical justification: A new page can be started at a specific position in a text by the inclusion of a code NP. If page breaks are not specified, a text of arbitrary extent is split into pages of the appropriate length by the photocomposing program. Any appearance of the IN or NP code starts a new page, and material for this page accumulates line by line in storage, until the cumulative vertical dimension of the output exceeds the specified page length. Two further lines then are set, and these and the preceding three lines examined to determine the appropriate page break. Standard conventions are adopted to avoid starting a paragraph on the last line. Any lines considered to be surplus are carried to the next page (except leading null lines) and the space needed to maintain the requisite page length is divided equally between spaces between lines except those lines which precede paragraphs.

● VI. Special Codes

A few further codes require special explanation.

(i) Output identification: A code of the form IDs, where s denotes a string of 6 bcd characters causes this string to be punched in the last 6 columns of the output cards produced by the program.

(ii) Zero set: The code ZS at a point in the text prevents escapement, i.e. all subsequent characters are displayed with the left edges of their fields coincident. The code NS restores normal spacing procedures.

(iii) Terminate output: The code EN terminates any input text expressed in ϕ code.

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